Il Colle di Galileo

The INO 2017 Annual Symposium

Physics Department, University of Trento, Polo Scientifico Tecnologico, Povo, Trento. February 9th – 10th, 2017

Organizer: National Institute of Optics of the National Research Council (CNR INO), BEC Center, Trento

Summary. The Annual Symposium of the National Institute of Optics brings together researchers from all local units of the Institute, as well as guests from other institutes of CNR and from academic communities, to present and discuss their most recent scientific results in a lively two-day meeting.

Keywords. Optics, Light, Vision, Sources, Health, Security, Spectroscopy, Interferometry, Microscopy, Metrology, Quantum optics, Systems and sensors, Quantum gases, Ultracold atoms.

The 2017 Annual Symposium of the National Institute of Optics (INO) is the fifth in a series of meetings which began in Arcetri in 2013. The aim of these meetings is to strengthen the connections between researchers of the Institute working in different local units of INO and different fields, as well as to create links with other research centres working in related areas. The 2017 edition was organized by the unit of INO at the Centre on Bose-Einstein Condensation (CNR INO BEC Center, Trento) and was held at the "Polo Scientifico e Tecnologico" of the University of Trento.

Optics plays a crucial role in the advancement of knowledge and in the development of key applications of physics to the modern world, including telecommunications, medical imaging, sustainable energy solutions, and quantum technologies. The National Institute of Optics has the ambition of staying at the forefront of these fields. In order to improve its capability to exploit all internal skills and the network of interdisciplinary collaborations, as well as to orient its activities along strategic lines, the Institute has recently reorganized its laboratories and groups in the following "macro-areas": sensors and imaging; novel light sources and extreme photonics; nano- and bio-photonics; metrology and spectroscopy; cold matter and quantum optics; advanced optical materials, components and systems. The scientific program of the Symposium was created from contributions of each macro-area, with a proper balance of topics covering the most recent progress.

The motto of the symposium was "shedding light on the quantum world" and was inspired by the growing worldwide interest in quantum science and technolo-

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gies. Major advances in this field are expected in the next years as a consequence of the decision of the European Commission to launch a flagship large-scale initiative in Quantum Technology with the aim of placing Europe on the frontier of the second quantum revolution. A first step in this direction is represented by the recent joint transnational call on Quantum Technologies research launched by QuantERA. The initiative covers six main topics: quantum communication; quantum simulation; quantum computation; quantum information sciences; quantum metrology sensing and imaging; novel ideas and applications in quantum science and technologies. Most of these themes lie at the heart of research work carried on at the National Institute of Optics. Hence the 2017 Annual Symposium was a timely opportunity to discuss the status of research activities at the different units of the Institute and to plan common strategies aimed at increasing the impact of INO in the context of such a challenging scientific endeavour.

The first day of the meeting was opened by an introduction by Paolo De Natale, CNR INO Director, and a welcome address by Lorenzo Pavesi, Director of the Physics Department of the University of Trento. The scientific session then started with the talk of Christian Roos from IQOQI, Innsbruck, on the physics of trapped ions. The speaker presented recent experimental progress in the manipulation of arrays of ions as a toolbox for quantum simulations, discussing Ising spin models as an important test-case. The next two talks were devoted to experiments with ultracold gases, namely, the experiments at LENS on high-precision quantum simulations with Yb atoms, and those in Trento on the direct observation of vortex-vortex interactions in Bose-Einstein condensates of sodium atoms. The morning session was closed by two talks on applications of optics to biomedical systems, in particular, the multi-modal imaging of rehabilitation-induced cortical plasticity and the optical treatment of cardiac arrhythmias. A poster session was organized in the afternoon, together with a tour of the ultracold atom laboratory of the CNR INO BEC Center and the Nanoscience laboratory of the Department of Physics. The last scientific session included talks on: new insights from imaging insect brains; synthesis and characterization of multifunctional metal oxide nanowires for sensing applications; relativitic plasmonics for ultrashort electron and XUV sources; and frequency comb generation by optical parametric oscillations.

The guest speaker of the second day was Philipp Treutlein from the University of Basel, who gave a general overview on Bell correlations in Bose-Einstein condensates and presented recent results on the detection of strong Bell correlations between the spins of about 480 Rubidium atoms. This many-body correlated state may be useful as a resource in quantum information processing. The issue of observing the entanglement in quantum simulators was also discussed in the next talk, followed by a presentation on how to realize synthetic dimensions in ultracold atomic gases and photonics. The other talks of the day were devoted to: plasma sources and diagnostics in laser-driven accelerators; applications of infrared digital holography; photonics and electronics for bright single-photon sources

based on colour centres in diamonds; optical resonator-based plasmonic sensors. The final session in the afternoon included talks on: optical waveguides and NV centres in diamonds fabricated with femtosecond laser pulses; nonlinear techniques for the disclosure of the internal structure of paintings; and metrological-grade nonlinear THz generation in Lithium Niobate waveguides.

The meeting provided a great opportunity to discuss funding strategies, not only in the context of the QuantERA network, but also in the framework of the "Key Enabling Technologies" identified by the European Commission, which include photonics, nanotechnology, micro- and nanoelectronics, advanced materials and biotechnology. It was also an occasion for reinforcing the presence of INO in Trento as a partner of a new initiative, called Q@TN - Quantum at Trento. This initiative involves several departments of the University, the Bruno Kessler Foundation (FBK) and CNR and aims to create a joint research centre on quantum science and technology by combining interdisciplinary competencies, infrastructure, facilities, and common research & education programmes. The first public presentation of Q@TN was held at the conclusion of the INO Symposium, with a round table led by Lorenzo Pavesi, Director of the Physics Department, Tommaso Calarco, from the University of Ulm, and Gianluigi Casse, Director of the Centre for Materials and Mycrosystems of FBK.

In conclusion, the Symposium was successful and timely. The INO Symposium was attended by 110 scientists, a large percentage of them being young researchers, PhD students and postdocs. It strengthened collaboration among different groups of the Institute and with scientists of other institutes and research centres, confirming the vitality of INO and its capacity to pursue important scientific projects in strategic research areas.

Figure 1. Group picture.